ABSTRACT

A new time-synchronization system for cabled underwater observation systems was developed and evaluated. It provides accurate GPS time signal (1PPS Signal) and accurate clock to underwater sensors. 1PPS signal is essential for longterm and continuous acoustical geodetic monitoring with cabled observation system. Geodetic observation on the seafloor is important in Japan for disaster mitigation, as most plate boundaries which cause mega-thrust earthquakes are placed under seafloor. The system will be installed in the Tokai-SCANNER which will be constructed off Toyohashi in central Japan. The evaluation tests show it can provide 1PPS signal of about 10 nanoseconds accuracy which surpasses the required accuracy for acoustical geodetic monitoring. This paper will describe the outline of the system and the results of evaluation test.

KEY WORDS: Time-synchronization, underwater, observation, geodesy, cabled-observatory, GPS,

INTRODUCTION

As cabled observation systems enable long-term continuous four-dimensional monitoring as they provide electric power and communication line to sensors deployed on seafloor. It can be used in many disciplinary such as seismology, oceanology, marine biology, etc.

One of its promising applications is a long-term acoustical geodetic monitoring. By monitoring the movement of acoustic transmission delay between acoustic transmitter and receiver deployed on seafloor for example, we can continuously monitor the deformation of seafloor over long time. If the system is connected with transducers and associated electronics for GPS/Acoustic combined systems, it also enables long-term and continuous geodetic monitoring. As most of plate boundaries around Japan, which periodically cause catastrophic earthquakes, are located beneath seafloor, long-term acoustic geodetic monitoring on seafloor close to plate boundaries is essential to understand the movement of plate boundaries for disaster mitigation.

For the acoustical geodetic monitoring, an accurate time-synchronization signal is needed. As the acoustic transmission velocity is about 1,500 meters/s, a time-synchronization signal of one microsecond accuracy is needed to ensure acoustical geodetic monitoring of about one millimeter accuracy.

The authors have developed a new time-synchronization system for cabled observation systems. The system provides precise GPS signal (1PPS signal), a clock of 1.25Mbit/s and NMEA data to sensors on seafloor. 1PPS signal is a pulse signal which is sent just every second synchronized to GPS time. NMEA is a standard data format used for GPS, including date, time, longitude/latitude receiver, altitude/depth of a receiver, etc. As to GPS, the system will provide the same environment to sensors on seafloor as that for terrestrial sensors connected with a GPS receiver. The 1.25Mbit/s clock will be used as a reference frequency for quartz pressure sensors connected to cabled observation systems. The developed system will be installed in Tokai-SCANNER which will be deployed off Toyohashi in central Japan.

The evaluation tests show it can provide 1PPS signal of about 10 nanoseconds accuracy which surpasses the required accuracy for acoustical geodetic monitoring. In this paper, after shortly introducing Tokai-SCANNER, the authors will describe the configuration of the system and the results of evaluation tests.

Tokai-SCANNER

A decommissioned underwater optical telecommunication cable off Toyohashi in central Japan will be used for Tokai-SCANNER (Fig.1). The cable was a portion of a domestic optical telecommunication cable network called Japan Information Highway (JIH), which surrounds Japanese Islands. It uses up-to date technologies of Dense Wavelength Division Multiplex (DWDM) and optical amplification. Tanaka et al. described the optical transmission capacity of JIH. It has three optical fiber pairs, and was constructed in 1999 by KDD (now KDDI).

There are two cables connected to the landing station in Toyohashi. One was linked to Shima, and another was linked to Ninomiya. In 2003, the landing portion of the east-side cable was broken. In order to resume the communication service quickly, KDDI avoided negotiation with fisherman unions and has directly connected two cables offshore, bypassing the landing portion of cables, and abandoned the landing